

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Borran, et al.
Title: PARTIALLY COHERENT
CONSTELLATIONS FOR
MULTIPLE-ANTENNA
SYSTEMS
Appl. No.: 10/671,346
Filing Date: 9/24/2003
Examiner: Kevin Michael Burd
Art Unit: 2611
Confirmation Number: 7074

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

DECLARATION UNDER 37 C.F.R. § 1.132

Sir:

I, Callie M. Bell, hereby declare the following:

1. I am an attorney of record for United States Patent Application No. 10/671,346, filed on September 24, 2003.
2. Attached as Exhibit A is a true and accurate copy of the webpage presented when I selected the link "Journal Articles" using a browser from the webpage <http://www.ece.rice.edu/~ashu/> on January 17, 2008. Exhibit A shows a reference to a journal article cited as M. J. Borran, A. Sabharwal and B. Aazhang, On Design Criteria and Construction of Noncoherent Space-time Constellations, IEEE Transactions on Information Theory, pp. 2332–2351, 49(10), October 2003.
3. Attached as Exhibit B is a true and accurate copy of the webpage presented when I selected a link from a webpage created by the Google™ web search engine using a browser on January 17, 2008. The Exhibit B shows the webpage at the uniform resource locator:

<http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/18/27735/01237124.pdf?arnumber=123712>.


Exhibit B shows a reference to an article cited as M. J. Borran, A. Sabharwal and B. Aazhang, On Design Criteria and Construction of Noncoherent Space-time Constellations, IEEE Transactions on Information Theory, pp. 2332-2351, 49(10), October 2003 and a summary of the article.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and believe are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

Dated: January 18, 2008

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By 

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Exhibit A

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Book Chapters
 Patents
 Journal Articles
 Conference Papers
 Theses
 Technical Reports

Journals

2003-present

- T. Moustakim, A. Sabharwal and B. Aazhang, Antenna Packing in Low-power Systems: Communication Limits and Array Design, to appear in *IEEE Transactions on Information Theory*, 2008.
- A. Sabharwal and U. Mha, Bounds and Protocols for a Rate-constrained Relay Channel, *IEEE Transactions on Information Theory*, May 2007.
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- A. Sabharwal, A. Muthukrishnan and E. Knightly, Opportunistic Spectral Usage: Bounds and a Multi-band CSMA/CA Protocol, in *ACM Transactions on Networking*, 2007.
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- B. Sadek, V. Parvathi, A. Sabharwal and E. Knightly, DAR: A Multi-rate Media Access Protocol for Wireless Ad Hoc Networks, in *ACM/Lower Wireless Networks: Special Issue on Mobile Computing and Networking*, 12(1), pp. 32-53, January 2005.
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- M. J. Borst, A. Sabharwal and B. Aazhang, On Design Criteria and Construction of Noncoherent Space-Time Constellations, *IEEE Transactions on Information Theory*, pp. 2330-2351, 49(10), October 2003.
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- V. Kulkarni, C. Li, A. Sabharwal, B. Sadek, and E. Knightly, Distributed Priority Scheduling and

Exhibit B

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Article Information

On design criteria and construction of noncoherent space-time constellations
 Borran, M.J.; Sabharwal, A.; Aazhang, B.
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Summary: We consider the problem of digital communication in a Rayleigh flat-fading environment using a multiple-antenna system, when the channel state information is available neither at the transmitter nor at the receiver. It is known that at high signal-to-noise ratio (SNR), or when the coherence interval is much larger than the number of transmit antennas, a constellation of unitary matrices can achieve the capacity of the noncoherent system. However, at low SNR, high spectral efficiencies, or for small values of coherence interval, the unitary constellations lose their optimality and fail to provide an acceptable performance. In this work, inspired by the Stein's lemma, we propose to use the Kullback-Leibler (KL) distance between conditional distributions to design space-time constellations for noncoherent communication. In fast fading, i.e., when the coherence interval is equal to one symbol period and the unitary construction provides only one signal point, the new design criterion results in pulse amplitude modulation (PAM)-type constellations with unequal spacing between constellation points. We also show that in this case, the new design criterion is equivalent to design criteria based on the exact pairwise error probability and the Chernoff information. When the coherence interval is larger than the number of transmit antennas, the resulting constellations overlap with the unitary constellations at high SNR, but at low SNR they have a multilevel structure and show significant performance improvement over unitary constellations of the same size. The performance improvement becomes especially more significant when an appropriately designed outer code or multiple receive antennas are used. This property, together with the facts that the proposed constellations eliminate the need for training sequences and are most suitable for low SNR, makes them a good candidate for uplink communication in wireless systems.

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